Intel IT Center

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White Paper

Intel's Vision of Open Cloud Computing

Executive Overview

Cloud computing is an important evolution in IT services delivery for the enterprise as well as for telcos, hosting companies, government agencies, and others. Some have fully embraced cloud computing to make IT more agile, efficient, and cost-effective in the delivery of services that support business growth. Others are in the early planning stages of cloud deployments. And, while the tools, building blocks, and best practices for the cloud are maturing, challenges to deploying cloud solutions still remain—especially as companies look to expand from private to public and hybrid cloud deployments.

Intel brings a comprehensive set of innovative technology, industry leadership, and expertise to help address key challenges in cloud computing adoption to make it easier for companies to realize the full benefits of cloud more quickly.

Intel has a vision for open cloud computing that is federated, automated, and client-aware. Realizing this vision requires a cloud infrastructure that is highly efficient, scalable, and secure, and is built on a foundation of open, interoperable, and multi-vendor solutions. This paper looks at Intel's open cloud computing vision and the company's contributions to ease adoption and enable more efficient, secure, and scalable clouds.

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IT Under Pressure

By 2016, over 3 billion connected users will drive an increase of more than 8x in mobile data traffic compared to 2012.[1] By 2020, there will be over 30 billion connected devices.[2] Moreover, information is growing at 2x per year[3] from the massive growth in structured data (traditional databases) and unstructured data (e-mail, web content, videos, social media).

IT is under pressure to become much more agile and efficient, while turning this increasing variety and volume of data into actionable insights. At the same time, data centers are often pushed to capacity, while IT resources and costs are constrained. Plus, there is a need to continually enhance security to keep ahead of increasingly sophisticated hackers. These challenges are driving the need for IT to quickly evolve toward a more efficient, automated, and secure infrastructure.

Speeding Agility, Reducing Costs, and Accelerating Innovation via Cloud

Cloud computing is an evolution of IT services delivery that offers a path to optimized use and rapid deployment of resources through systems and solutions that are more efficient and scalable, while providing much greater levels of automation. Many enterprises have embraced cloud computing, thus realizing significant benefits in agility, cost reduction, and delivering new services faster to support business growth. Other organizations are in the planning stages for cloud deployments or still considering their plans.

Cloud infrastructure technologies and solutions are maturing, offering software solutions and systems to more widely and easily implement private clouds and extend into public and hybrid clouds.

From Virtualization to Cloud

For many enterprises, virtualized server infrastructure is the foundation upon which cloud infrastructure is built. Initially, virtualization technologies allowed data centers to consolidate server infrastructure to save cost. Over time, integrating flexible resource management technologies enabled more dynamic allocation of data center resources. This has helped reduce costs and also increased data center flexibility and performance. However, it's also led to Virtual Machine (VM) sprawl, leading to further complexity.

Cloud computing extends highly virtualized infrastructure to bring significant automation and new levels of scalability. Software providers continue to expand solutions to provide robust management features and technology optimizations for cloud deployments based upon virtualization. Hardware vendors, too, have extended their management tools and reliability features to include increased flexibility and resource orchestration.

Cloud deployments are different from previous IT services implementations. The key attributes that distinguish cloud computing from traditional IT are:

- Compute and storage functions are abstracted and offered as services.
- Services are built on a massively scalable infrastructure.
- Services are delivered on demand through dynamic, flexibly configurable resource pools.
- Services are easily purchased and billed by consumption.
- Resources are shared among multiple users (multi-tenancy).
- Services are accessible over the Internet or internal network by any authenticated device.

Cloud Adoption Challenges Remain

Cloud services often rely on virtualization technologies, enabling service portability, migration, and recovery, among other practices. Though cloud computing can be considered an evolutionary step from virtualized environments, cloud computing is a fundamental shift. Cloud deployments have unique challenges, including the following:

- Maintaining the stability of mission-critical applications as the enterprise transitions to cloud environments is paramount.
- Protecting and securing intellectual property, data, and privacy requires additional attention and new tools if shared resources in a public cloud are to be used.
- The automation, flexibility of resource pools, and integration across both private and public cloud infrastructure will be imperfect as tools and standards continue to mature.
- Providing flexible and interoperable solutions is essential to successful, wide-spread adoption.
- Ensuring that cloud-based applications enable user productivity, rather than degrade it – regardless of the device used or connectivity.

The Three Elements of Intel's Vision of Open Cloud Computing

Cloud computing technology is maturing quickly, and many technology and solutions providers have entered the market to enable the development of private clouds for enterprise IT. Additionally, several public cloud providers are expanding their services to better meet the demands of the enterprise. In Intel's numerous conversations with vendors, customers, and industry thought leaders, the company has identified key themes that are critical to what customers seek from cloud computing solutions.

Intel's Vision for Open Cloud Computing focuses on helping to overcome key challenges and realize the full potential and value of cloud computing. The three key themes are clouds that are federated, automated, and client-aware.

Federated

Federated means communications, data, and services can move easily within and across cloud computing infrastructures. Intel's Vision for Open Cloud Computing calls for a level of federation that enables the following:

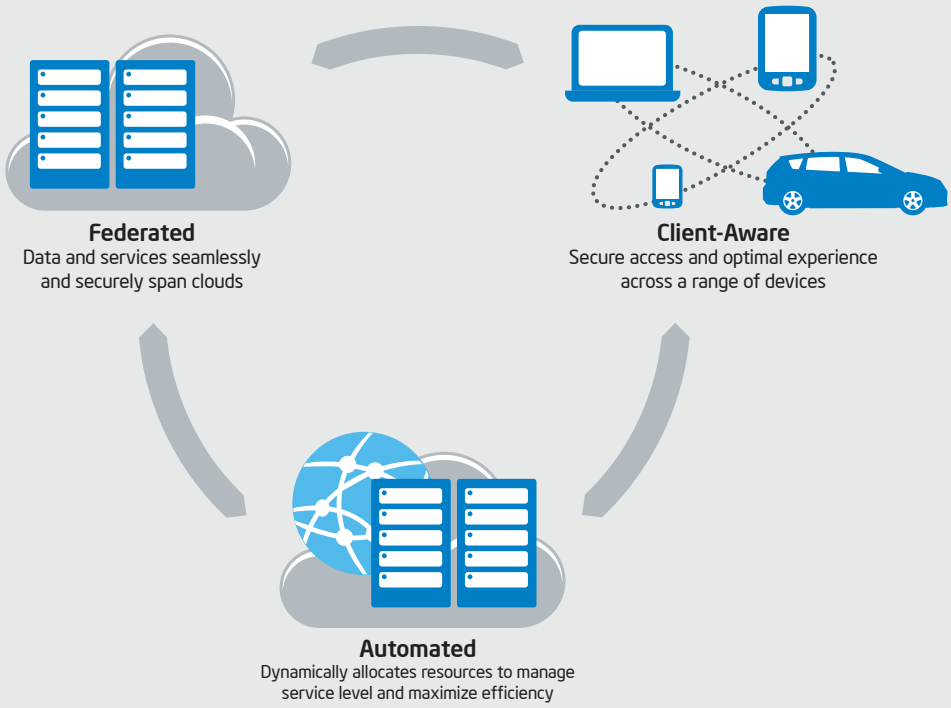
- The seamless movement of workloads and data from one service provider to another.
- Burst implementations between internal private cloud and public cloud providers if additional capacity is needed.
- Secure and reliable data flow across vendors, partners, and clients.

The industry has evolved to the point that enterprises can move or migrate workloads within and between their own data centers. And solutions to connect private and public clouds, such as federating user identities, are emerging. But, to enable truly federated systems, seamless interoperability across many platforms and solutions must be a reality.

Some leading companies are starting to deploy hybrid clouds by connecting private and public clouds, though such connectivity requires a potentially sizeable investment to implement. However, most data center operators are not yet implementing such configurations, where data and services seamlessly and securely scale beyond their borders, due to lack of technology maturity, financial limitations, need for organizational changes, or other reasons.

Intel's vision for federated solutions calls for seamless, interoperable services across disparate infrastructures that maintain required service levels and security policies.

Intel's Open Cloud Vision



Automated

Automated means that cloud computing services and resources can be specified, located, and securely provisioned with very little – or zero – human interaction. Intel's Vision for Open Cloud Computing calls for automation that dynamically allocates resources and manages data according to agreed-upon service levels, and optimizes the data center for maximum resource utilization and power efficiency. This includes automated provisioning, resource monitoring, reporting of consumption for bill-back, and policy-based workload balancing.

Today, the pervasive deployment of virtualization has helped increase efficiency through consolidation; however, as mentioned earlier, this has also led to Virtual Machine (VM) sprawl and increased complexity. Moreover, VMs are still generally statically provisioned rather than deployed based on policies that automatically respond to user needs. Finally, data center management remains manual for many IT departments. For example, patching of servers doesn't scale reliably across large-scale installations.

A growing number of companies are now realizing greater agility through automation based on solutions for policy-based VM migration, self-service portals for resource provisioning, monitoring tools for capacity planning, and other practices. However, there remain gaps in automation due to technology maturity, organizational responsibilities, and other barriers.

Intel's vision for automation calls for the infrastructure to provision, migrate, and manage services with as little human intervention as possible (ideally none).

Client-Aware

Client-aware means that cloud-based applications are able to recognize individual client device capabilities to adapt and optimize application delivery securely, while enhancing the user's experience. Intel's Vision for Open Cloud Computing calls for the infrastructure to sense end-point attributes and then adjust service delivery to take advantage of the device's capabilities without risk to data or user identity. These attributes include the device's remaining battery life, policies, connectivity, security, graphic and compute capabilities, and others.

When it comes to the ability to access, display, manipulate, or secure data, clearly some devices are more capable than others. These capabilities can affect the overall delivery of cloud solutions when considered by the data center infrastructure. For example, delivering data to be rendered on a highly capable mobile platform can produce a better user experience than rendering in the data center and transferring the visualization over a slow mobile network to the device. Additionally, there are more location-based Internet services that can recognize user identities, but not the security policies to which the device is expected to adhere. Recognizing security policies on the client helps ensure policies are applied at the device. Most Internet services, however, do not recognize all of the key individual device capabilities, and thus are not delivering a fully customized and optimized user experience.

Today, certain frameworks accommodate some level of data center intelligence and scaling to adapt to the client being served, but they are neither ubiquitous nor consistently applied. Certainly, the number of Internet services tailoring their applications to particular client device types such as mobile smartphone, including location-based services, basic identity, and screen size, continues to grow. But, many Internet services still assume the lowest common denominator device. Thus, when a user accesses the service with something more capable, such as a high-performance Ultrabook,™ the data center sacrifices efficiency, while the user receives a less optimal experience. Conversely, other services are difficult to use on a handheld, because they were written for a desktop or notebook.

Intel's vision for a client-aware cloud calls for matching the service to the capabilities of the customer's device.

Foundation to Enable Open Cloud Computing

While great progress continues to be made, evolving the infrastructure to realize the full potential of cloud computing continues to be non-trivial. More progress requires cooperative development and specific focus by many technology and infrastructure providers and customers across the IT landscape.

Intel believes that to achieve open cloud computing, individual organizations and the IT industry as a whole need to focus on three key areas — efficiency, scalability, and security — built on open, interoperable solutions based on industry standards.

Efficiency, Scalability, and Security

Efficiency — The need for computing throughput continues to dramatically increase, but resources are limited. These resources include space, power, cooling capacity, qualified IT professionals, and sufficient budgets for infrastructure and operations. Doing more with existing or available resources will require increased efficiency from infrastructure and processes.

Scalability — Generally, the growth of a system inherently increases its complexity, and this is certainly true of IT infrastructure. Systems from different vendors typically present integration complications, and multiple architectures complicate infrastructure management. For cloud computing environments to deliver on their promise, simplification must underlie cloud architectures and practices in order to realize the scale and performance needed for reliable and fast delivery of IT services. Increased server utilization — especially when servers are virtualized — raises network bandwidth requirements and drives the need for more capable networks, which also need to be virtualized. Software-defined networking is emerging as a potential solution to improve network flexibility and capability.

Security — Both business risk and compliance requirements make data security essential. In an environment with abundant traditional security issues, cloud computing creates new challenges, because it moves data in new ways, often outside of traditional physical boundaries. The successful implementation of cloud computing requires new security models and technology implementations to meet these new challenges.

Standards-based Open and Interoperable Solutions

To achieve open cloud computing, solutions must easily interoperate across cloud environments based on industry standards. When multiple providers of solutions, hardware, software, integration, or processes act independently, vendor lock-in, poor interoperability, and lack of flexibility naturally result. These outcomes directly contradict the main benefits of cloud computing.

Learn More about Implementing Private and Hybrid Clouds

From Virtualization to a Self-Service IaaS Cloud
An IT manager guide from Intel for building on virtualization and cloud computing technologies to implement private cloud Infrastructure as a Service (IaaS), including a frame-work that lays the foundation for eventually moving to a hybrid model.

www.intel.com/content/www/us/en/cloud-computing/cloud-computing-virtualization-building-private-iaas-guide.html

Intel's Role in Achieving Open Cloud Computing

To meet the challenges of enabling wider cloud adoption and reducing the risks that IT architects and managers face, Intel is active on many fronts:

- Working with leading enterprises and service providers to understand their requirements.
- Driving technology innovation to address inherent challenges.
- Enabling optimized solutions across a broad ecosystem.
- Engaging with standards bodies to enable open standards focused on cloud deployments.

This holistic approach aids in simplifying the delivery of cloud services by helping remove barriers to innovation and speeding the delivery of technology and solutions for more secure, efficient, and scalable cloud data centers designed to preserve IT flexibility and choice.

An example of working with leading cloud providers and enterprises is Intel's role as the technical advisor to the Open Data Center Alliance (ODCA). Intel also uses insight from its engagements with leading systems and solution providers to develop reference architectures and best practices offered through the Intel® Cloud Builders program. And for organizations seeking to use public cloud infrastructure services, Intel® Cloud Finder makes it easier to select providers that meet an organization's requirements.

Open Data Center Alliance

The ODCA is an independent organization of over 300 leading global IT managers who amplify their collective voice by documenting best-of-breed data center requirements for today and the future. These requirements enable flexibility and choice. The ODCA's mission focuses on delivering next-generation data center and cloud requirements to meet the challenges facing IT today and tomorrow and delivering them in an open, industry-standard, and multi-vendor fashion. Intel responds to these requirements, and others that it identifies through its end-user engagements, with products and technologies designed to address the requirements.

To learn more, visit www.opendatacenteralliance.org.

Intel® Cloud Builders

The Intel Cloud Builders program brings together leading systems and software solutions vendors to provide best practices and practical guidance on how to deploy, maintain, and optimize a cloud infrastructure based on Intel® Architecture. Intel Cloud Builders provides the industry a central point for cloud innovation based on the IT requirements defined by the ODCA and other IT end users. Intel Cloud Builders publishes detailed reference architectures, success stories, and best practices that IT can use right now to deploy and enhance their cloud infrastructure. Using this guidance and interaction with cloud systems and solutions providers, IT managers can improve cloud security and efficiency, while simplifying data center management and operations.

Learn more at www.intelcloudbuilders.com.

Intel® Cloud Finder

To better equip IT managers worldwide with the knowledge and answers they need to take full advantage of public cloud capabilities, Intel provides Intel Cloud Finder. Users visiting Intel Cloud Finder are first asked questions to define the required and desired features of their public cloud Infrastructure as a Service (IaaS) across multiple categories, including security, usability, quality, availability, technology, and business. The tool then compares user responses to the services available from a broad range of leading IaaS providers worldwide and returns matching results. Users can learn more about each provider and reach out to matching providers to take the next step. Intel Cloud Finder can significantly shorten the time it takes to identify an appropriate public cloud provider.

Learn more at www.intelcloudfinder.com.

Intel® Technologies Provide the Foundation for More Efficient, Secure, and Scalable Clouds

Intel provides leading technologies that offer a wide range of capabilities that are at the heart of more efficient, secure, and scalable cloud infrastructure. The Intel® Xeon® processor E5 family delivers leading efficient performance that helps IT dynamically scale to adapt to fluctuating workloads and increasing network and storage demands.[4] Hardware-based security enables isolation, visibility, and control of dynamic, virtualized workloads and data center infrastructure. It also provides up to 10x faster[5] encryption and decryption to reduce the overhead often associated with data encryption, which enables pervasive use of encryption to protect sensitive data.[4,6]

To handle significant increases in network traffic, Intel® 10 Gigabit Ethernet (10 GbE) adapters deliver up to 2x bandwidth improvements and up to 45 percent power savings,[7,8] while providing a more simplified data center infrastructure.[4] Intel is also accelerating companies' migrations to flexible software-defined networks via open solutions and reference designs. Finally, to cope with explosive growth in data, Intel delivers significantly high-performance and power-efficient storage via enterprise-class Intel® Solid-State Drives (Intel® SSDs) and enables efficient storage systems, such as those based on the Intel Xeon processor E5 family that use the Intel® Storage Acceleration Library (ISA-L).

About Cloud Delivery Models

- **Private –** Cloud infrastructure is provisioned for use by a single organization that comprises multiple tenants. Private clouds may be operated on- or off-premises and are behind the company firewall.
- **Public –** A cloud service provider offers services to multiple businesses, academic institutions, government agencies, and other organizations with access via the Internet.
- **Hybrid –** Hybrid clouds combine two cloud delivery models (for example, private and public) that remain unique as entities but are bound together by technology that enables data and application portability. Cloudbursting is an example of one way enterprises use hybrid clouds to balance loads during peak demand periods.
- **Community –** Cloud infrastructure is provisioned for the exclusive use of a specific community of user organizations with shared computing requirements such as security, policy, and compliance.

Conclusion

Many companies are realizing benefits from cloud deployments, though challenges in adoption still remain. For example, expanding from private to hybrid clouds will require continued advancements in open standards, interoperable solutions, and security.

Intel is working with leading enterprises, cloud service providers, and a broad range of solutions partners to identify key requirements and enable solutions to address challenges in cloud adoption. Intel's Vision of Open Cloud Computing is focused on working with the industry to enable interoperable solutions that provide flexibility and choice. Intel technologies are at the foundation of cloud deployments today because they provide more scalable, secure, and efficient cloud infrastructure.

To learn more about Intel's Vision of Open Cloud Computing, IT best practices around cloud deployments, and how to evolve your infrastructure to be more efficient, scalable, and secure, visit www.intel.com/cloud.

More from the Intel® IT Center

Intel's Vision of Open Cloud Computing is brought to you by the Intel® IT Center, Intel's program for IT professionals. The Intel IT Center is designed to provide straightforward, fluff-free information to help IT pros implement strategic projects on their agenda, including virtualization, data center design, cloud, and client and infrastructure security. Visit the Intel IT Center for:

- Planning guides, peer research, and solution spotlights to help you implement key projects
- Real-world case studies that show how your peers have tackled the same challenges you face
- Information on how Intel's own IT organization is implementing cloud, virtualization, security, and other strategic initiatives
- Information on events where you can hear from Intel product experts as well as from Intel's own IT professionals

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[1] Cisco Visual Networking Index, February 2013.

[2] ABI Research, 2013.

[3] IDC: Extracting Value from Chaos, June 2011.

[4] Software and workloads used in performance tests may have been optimized for performance only on Intel® microprocessors. Performance tests, such as SYSmark* and MobileMark*, are measured using specific computer systems, components, software, operations, and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products.

[5] http://www.oracle.com/us/corporate/press/173758.

[6] Source: Testing with Oracle Database Enterprise Edition 11.2.0.2 with Transparent Data Encryption (TDE) AES-256 shows as much as a 10x speedup when inserting one million rows 30 times into an empty table on the Intel® Xeon® processor X5680 (3.33 GHz, 36 MB RAM) using Intel® IPP routines, compared with the Intel® Xeon® processor X5560 (2.93 GHz, 36 MB RAM) without Intel IPP.

[7] This ROI calculator is a cost comparison for a highly virtualized solution, using multiple 1 GbE connections versus a dual-port 10 GbE implementation. In the 1 GbE solution we use two Intel® Gigabit ET Quad Port Server Adapters in each server, in addition to two LOM connections with a total system bandwidth of 10 Gb. This is then compared with a 10 GbE solution, using one Intel® 10 Gigabit AF DA Dual Port Server Adapter and a total system bandwidth of 20 Gb. These adapters are connected to a top-of-rack 10 GbE switch using passive direct attach twinax coax cables. Refer to http://www.event-management-online.de/LAD/calculator.aspx

[8] Results based on Intel® Ethernet Server Adapter ROI tool: http://www.event-management-online.de/LAD/calculator.aspx. Bandwidth claim based on assumed configuration of ten One Gigabit Ethernet (GbE) adapters (10Gb total bandwidth) or two 10 Gigabit Ethernet Adapters (20Gb total bandwidth). Power consumption figure based on comparison of Blade Networks Rackswitch G8000 and GbE adapter configuration vs. Juniper EX2500 and 10GbE adapter configuration.

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